

Anatomy of the Lower Extremity

Introduction

This first Lower Extremity lesson is like the first Upper Extremity lesson, and introduction. It is intended as an introduction for learners who have not engaged this content previously, and as a review for those who have. We're going to use the compartment model throughout the next three lessons. This is a consolidated way of approaching the lower extremity that is not intuitive or overly detailed. Even if you already know the lower extremity anatomy really well, engage in this lesson fully. It will get you set up with how we teach this content over the next two lessons.

This lesson is going to cover the bones, muscles, and motor innervations of the lower extremity. There are five bones: pelvis, femur, patella, fibula, and tibia. The muscles are going to be discussed in terms of compartments, not the individual muscles themselves. There are three levels of the lower extremity: hip, leg, foreleg. There are a total of eight muscle compartments: two in the hip, three in the leg, and three in the foreleg. There are eight arteries and eight motor nerves, each of which innervates and irrigates one compartment. It is your job to be able to pair each compartment with its artery and nerve, and to know what contraction of the muscles in that compartment does to the lower extremity. We're going to build your knowledge—bones first, then compartment, then muscles with their motor innervation, then arteries. At the end, you'll have a complete lower extremity.

Some clarity on our style. If muscles are mentioned but not **bolded**, it's so you know we did our homework, and maybe even for reference. We considered leaving them out altogether, so you would not be tempted to memorize them. We thought it better to be thorough, but to caution you that if it isn't bolded, you shouldn't spend time committing it to memory. The compartments are more important than the muscles themselves.

Some clarity on nomenclature. *When discussing the lower extremity, peroneal, fibular, and lateral are the SAME thing.* This is not an OME-ism; this is how anatomists named things. Peroneal is simply the Greek-derived term for things related to the fibula (the Greek and Latin root words both mean “pin” or “brooch”), and both terms—peroneal and fibular—are used in the naming of arteries and nerves. When naming compartments, lateral is used. If you see one, you should say the others out loud. The lateral compartment of the foreleg is irrigated by the fibular/peroneal/lateral artery and by the superficial fibular/peroneal/lateral nerve.

Finally, some clarity on a pun that isn't a pun. We use the word “foreleg” to refer to the region between the knee and ankle. We do this for clarity and to mirror the nomenclature of “forearm.” Other ways of saying it, despite using accepted terminology, confuse learners. “*Distal lower extremity*” takes too long to say and could mean “*only the region just above the ankle*.” “*Leg*” could mean the entire lower extremity, or what we mean by foreleg. Technically, a foreleg is either of the front two legs of a four-legged animal. We aren't using foreleg erroneously, or as a joke. It helped us keep things straight when we were learning it, and we're hoping it will help you, too. Just . . . don't go around telling your anatomy professors you are dissecting the foreleg of your cadaver (unless you want a giggle).

Bones of the Lower Extremity

There are five bones you have to know—pelvis, femur, patella, tibia, fibula. Do not learn the bones of the feet except for the few we teach you in the next lesson.

The **pelvis** stabilizes the core. It is the insertion and origin for many major muscles. It is the base of the axial skeleton and is the origination for the large muscles that control the femur/hip and humerus/shoulder. There isn't much to memorize about the pelvis bone's structure other than being able to name

the different parts. The **ilium** is the wing; you can feel the ilium's posterior and superior portion (the landmarks for a lumbar puncture) on the back of a patient. The **ischium** is the inferior and anterior marker for anesthesia during labor. The **pubis** sits just behind and above the ischium. Related to the pelvis is the **sacrum** (terminal portion of the spine) and **coccyx** (tailbone). The **acetabulum** of the pelvis is the socket of the hip joint.

The **femur** is the thigh bone, equivalent to the humerus of the arm. It has a head, a neck, a greater trochanter, and a lesser trochanter. The femur ends with a medial condyle and a lateral condyle. The head of the femur forms the ball of the ball-and-socket joint at the hip, and the condyles contribute to the knee.

The knee also involves the **patella**, which is a separate bone from the femur.

The foreleg consists of a large medial bone called the **tibia**, and a much smaller lateral bone called the **fibula**. The arteries and nerves will be named in reference to these bones. The fibula cannot withstand the weight of body. If the tibia breaks, the fibula will follow. The fibula is there for ligaments and muscles to attach to so the ankle can work, and a little for the knee.

The feet have **tarsals**, **metatarsals**, and phalanges. There are MCPs, DIPs, and PIPs, just as in the hand, including the "thumb toe" (digit 1, the great toe) which, similar to the thumb, has only two joints. In the lesson on joint pathology we will identify a few bones of the foot you should be aware of.

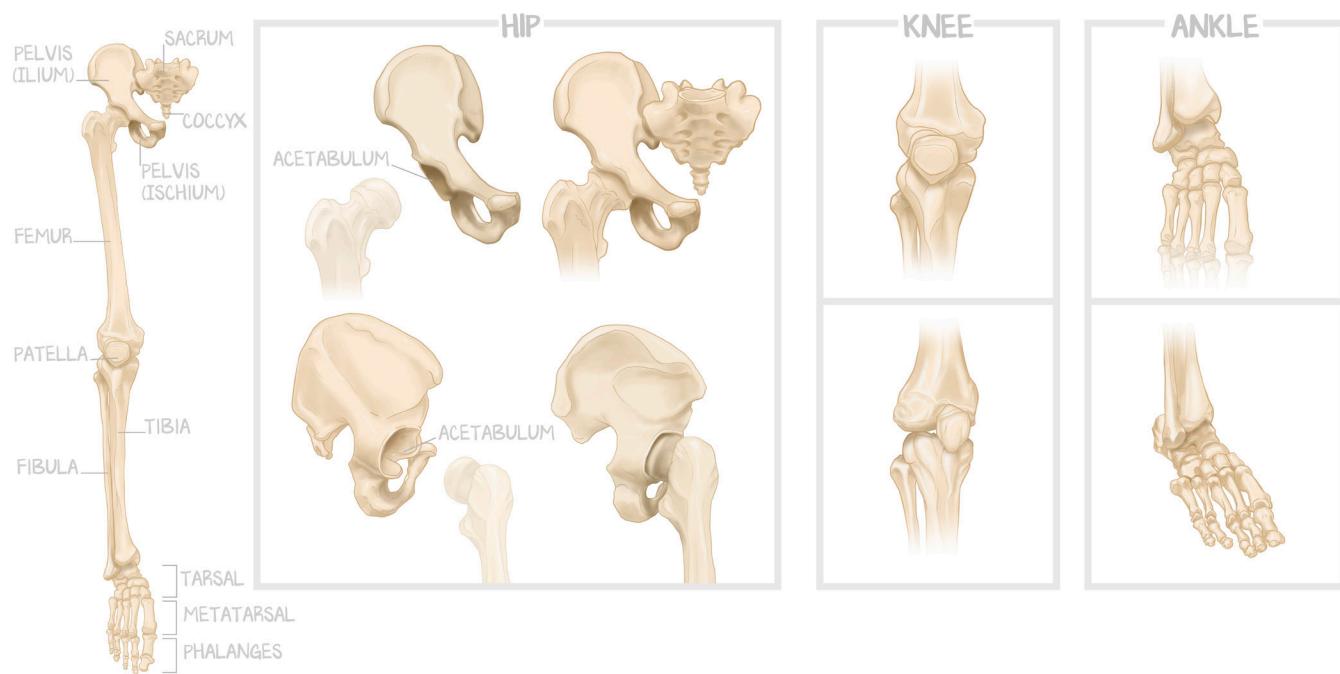


Figure 4.1: Bones of the Leg

An overview of the large bones of the lower extremity and details of the major joints—hip, knee, and ankle.

Muscle Compartments of the Lower Extremity

We want you actively—not learning individual muscles, but rather separating them into compartments. Each compartment is made up of multiple muscles and each of those muscles does one movement when it contracts. One compartment, one motor innervation, one artery, one action. Unfortunately, the sensory innervation doesn't work quite so simply, so we will need to get into specifics in MSK #6: *Nerves of the Lower Extremity*.

There are eight compartments—two in the pelvis, three in the thigh, three in the foreleg.

The two pelvic compartments are the **gluteus** compartment, which does hip extension and external rotation, and the **abductor** compartment, which does femur abduction and internal rotation.

The three thigh compartments are the **anterior** compartment, which does hip flexion and knee extension, the **posterior** compartment, which does hip extension and knee flexion, and the **medial** compartment, which does adduction.

The three foreleg compartments are the **anterior** compartment, which does dorsiflexion and inversion of the foot, the **posterior** compartment, which does plantarflexion and inversion of the foot, and the **lateral** compartment, which does eversion of the foot.

Pelvis Muscles: The Gluteal Compartment and Abductor Compartment

Technically speaking, there are two sets of muscles at the pelvis—the superficial muscles (gluteus muscles) that do extension and abduction of the hip, and the deep muscles (the other ones) that do external rotation of the hip. We want you learning it a different way. There is a gluteal compartment that contains only the gluteus maximus that does hip extension, an abductor compartment (gluteus medius and gluteus minimus, which we call collectively *gluteus otherus*), and a bunch of muscles you shouldn't learn that do external rotation of the hip. Stay focused on gluteal compartment and abductor compartment only.

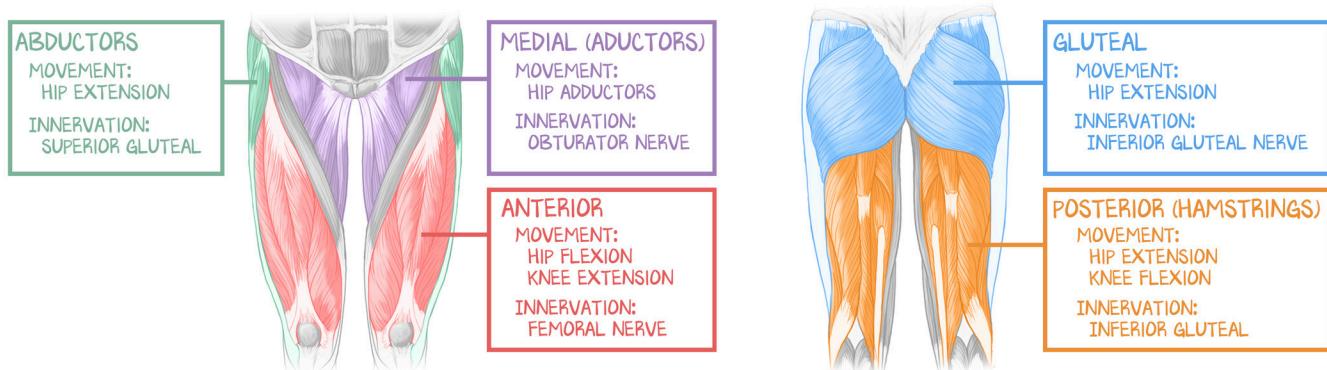


Figure 4.2: Muscles of the Pelvis and Thigh

We cheat a lot in this image. The three compartments of the thigh (medial: adductors; anterior: quadriceps; posterior: hamstrings) are accurate. But then we separate the pelvis compartments the way we want you to learn them—the gluteal compartment being only gluteus maximus and the abductor compartment being only the other gluteal muscles. This model is anatomically inaccurate and leaves many details out. But this model is also functionally ideal for learning and exam preparation.

The **gluteal compartment** is synonymous with gluteus maximus and is the big butt muscle. It reaches from the posterior ilium and sacrum to the lesser trochanter of the femur—from the back of the pelvis to the back of the femur. Contracting that muscle would pull the femur backwards. This is **hip**

extension. The nomenclature for the nerves that innervate the pelvis compartments are named for where the compartment inserts on the femur. The gluteus maximus may be the most superficial muscle in the pelvis, but is innervated by the **inferior gluteal nerve** because the insertion of the gluteus maximus is below (inferior to) the other gluteus muscles on the femur.

The **abductor compartment** is synonymous with *gluteus otherus* and is responsible for **abduction** and **internal rotation** of the hip. More importantly, these muscles act as the **stabilizing muscles of locomotion.** While walking, these muscles contract to ensure that the pelvis stays even on both sides, preventing a pelvic drop in the opposite limb (Trendelenburg's sign, discussed in MSK #6: *Nerves of the Lower Extremity*). These muscles are innervated by the **superior gluteal nerve** because they insert onto the femur above the gluteus maximus.

The deep muscles are included for thoroughness; nothing in this paragraph is bolded. The deep muscles of the hip (piriformis, gemelli, obturator, quadratus) are responsible for external rotation of the hip. These are important muscles in physical therapy, routine health, back pain, etc., but are just not worth the extra effort of memorizing for your licensure exam. They are there. They matter to humans. Leave them out of the compartment model. You've enough to learn in the leg as it is.

Thigh Muscles: Anterior, Medial, and Posterior Compartments

There are three compartments in the thigh: medial, anterior, and posterior. The medial adducts the femur and opposes the abductor compartment of the pelvis. The anterior compartment and the posterior compartment oppose one another, the contraction of the compartment moving both the knee and the hip.

The **medial compartment** is designed for **adduction at the hip** and is innervated by the **obturator nerve.** Almost all the muscles in this compartment have "adductor" in their name (obturator externus, adductor longus, adductor brevis, adductor magnus). Obturator externus—the only one without adductor in its name—is also the name of the nerve that innervates the compartment. So we recommend you learn, "*medial thigh, adduction, obturator*," simplifying this compartment.

The **anterior compartment** of the thigh (think **quadriceps** and **iliacus**) is innervated by the **femoral nerve.** The anterior compartment does two things—**flexion at the hip** and **extension at the knee.** Flexing the hip is bringing your leg up in front of you, extension of the knee is straightening the leg. Associate the quadriceps with flexion of the hip, iliacus with extension of the knee, and the other ones (pectineus and sartorius) as small and irrelevant. Learn, "*anterior thigh, hip flexion, knee extension, femoral nerve.*"

The **posterior compartment** (colloquially referred to as hamstrings) is designed for **extension at the hip** and **flexion at the knee** and is innervated by the **sciatic nerve.** Extension at the hip means pushing your heel backwards from a standing position. Flexion at the knee means bringing your heel to your butt. The "hammies" are the semitendinosus, semimembranosus, and **biceps femoris.** If you think of the knee like the elbow, these names make sense. You want to flex your elbow? Use your biceps. You want to flex your knee? Use your biceps. Learn, "*posterior compartment, hip extension, knee flexion, sciatic nerve.*"

COMPARTMENT	ACTION	INNERVATION
Gluteal compartment	Extension at hip	Inferior gluteal nerve
Abductor compartment	Abduction at hip Internal rotation at hip	Superior gluteal nerve
Medial compartment of the thigh (adductors)	Adduction at hip	Obturator nerve
Anterior compartment of the thigh (quadriceps)	Flexion at hip Extension at knee	Femoral nerve
Posterior compartment of the thigh (hamstrings)	Extension at hip Flexion at knee	Sciatic nerve

Table 4.1: Muscles of the Hip

The gluteal compartment and the abductor compartment are complex, in this table separated into *gluteus maximus*, *gluteus otherus*, and deep muscles of the hip you shouldn't remember. The rest of the hip muscles are lumped together into three compartments, cooperate within the compartment, and are innervated by the same nerve as the rest of the muscles in the compartment.

Foreleg Compartments: Anterior, Posterior, Lateral

The foreleg is frustratingly complex. In the thigh, anterior and posterior compartments oppose one another and the medial does something different. The foreleg, however, is not so conveniently arranged. The anterior compartment and posterior compartment contribute (they work together) to invert the foot while the lateral compartment does eversion. Then the anterior compartment does dorsiflexion of the ankle and extension of the toes while the posterior compartment does plantarflexion of the ankle and flexion of the toes. The nerves don't line up, either, the tibial going to the posterior and the branches of the peroneal/fibular going to the other two. What we recommend for this section is to see each compartment as a line item discrete from the others. Don't try to deduce a compartment's action or innervation based on the relationship of the compartments (e.g., anterior/posterior does not match superficial/deep).

The **anterior compartment** is responsible for **dorsiflexion and inversion** at the ankle, as well as **extension of the toes**. In a seated position, put your feet flat on the ground. Pull your toes back toward you. The muscles that are anterior and lateral of the tibia contract (if you can't tell, hold that contraction to feel the burn), the foot comes towards you, and the toes flare. Now try to look at the bottom of your foot by turning it inward. This is inversion at the ankle. These muscles are innervated by the **deep peroneal/fibular nerve**. The muscles of this compartment are the tibialis anterior (very well named), and the toe extensors (extensor digitorum longus, extensor hallucis longus).

The **posterior compartment** is the most complex and is often separated into two subcompartments. Don't do that. Learn the posterior compartment as one common compartment, the compartment that opposes the anterior compartment. The posterior compartment does **plantarflexion, flexion at the toes** (opposing the anterior compartment as expected), and **inversion** at the ankle (the same function as the anterior compartment). Both the anterior and posterior compartments invert the foot. The posterior compartment pulls the foot down and curls the toes, while the anterior compartment pulls the foot up and flares the toes. The posterior compartment is innervated by the **tibial nerve**. This is what you think of as your calf.

The **lateral compartment** is a small compartment. It is the fibular/peroneal/lateral compartment. The fibularis longus and brevis are responsible for **eversion at the ankle** and are innervated by the **superficial peroneal nerve** (superficial fibular nerve). The superficial peroneal (fibular) nerve innervates the fibular (lateral) compartment, and does eversion of the ankle.

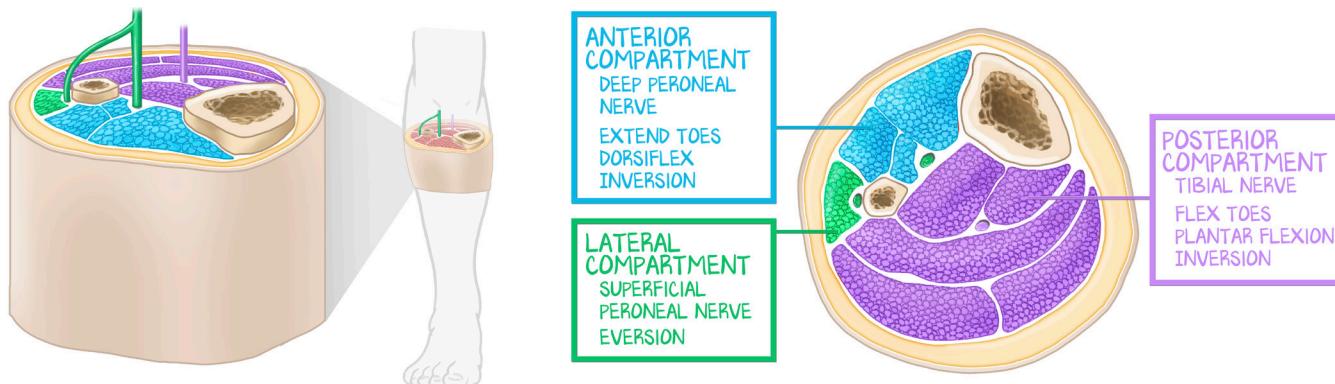


Figure 4.3: Compartments of the Foreleg

The foreleg is divided into three compartments—anterior, lateral, and posterior. Each compartment has its own vascular supply, its own nervous innervation, and its own function.

COMPARTMENT	MUSCLES	ACTION	NERVE
Anterior	Tibialis anterior Extensor "etceterus"	Extension of toes Dorsiflexion at ankle Inversion at ankle	Deep peroneal/fibular
Posterior	Tibialis posterior Gastrocnemius Plantaris	Flexion of toes Plantarflexion at ankle Inversion at ankle	Tibial nerve
Lateral	Fibularis longus Fibularis brevis	Eversion at ankle	Superficial peroneal (fibular)

Table 4.2: Muscles of the Foreleg

Notice the similarities and differences between the anterior and posterior compartments—they have tibialis muscles and move the foot and toes. Then the lateral compartment has only fibular muscles and does only eversion at the ankle.

The Arteries of the Leg

In the upper extremity lesson we discussed neurovascular pairings. In the leg, there are neurovascular pairings as well. But because the name of the artery so rarely matches the name of the nerve, we suggest you learn the arteries separate from the nerves. We're still talking in terms of one compartment to one artery, and you've just learned one compartment one nerve above. This does lend itself well to flashcards and table studying.

The external iliac artery (within the pelvis) changes name to the **femoral artery** as it passes under the inguinal ligament and enters the femoral triangle. The **femoral artery irrigates all gluteus compartments and thigh compartments**. The only special artery worth committing to memory in the thigh has nothing to do with compartment irrigation. The **medial femoral circumflex artery**, which supplies the neck and

head of the femur has implications for hip fractures and avascular necrosis (discussed in MSK #5: *Joints of the Lower Extremity*). Do not learn the individual branches of the femoral artery.

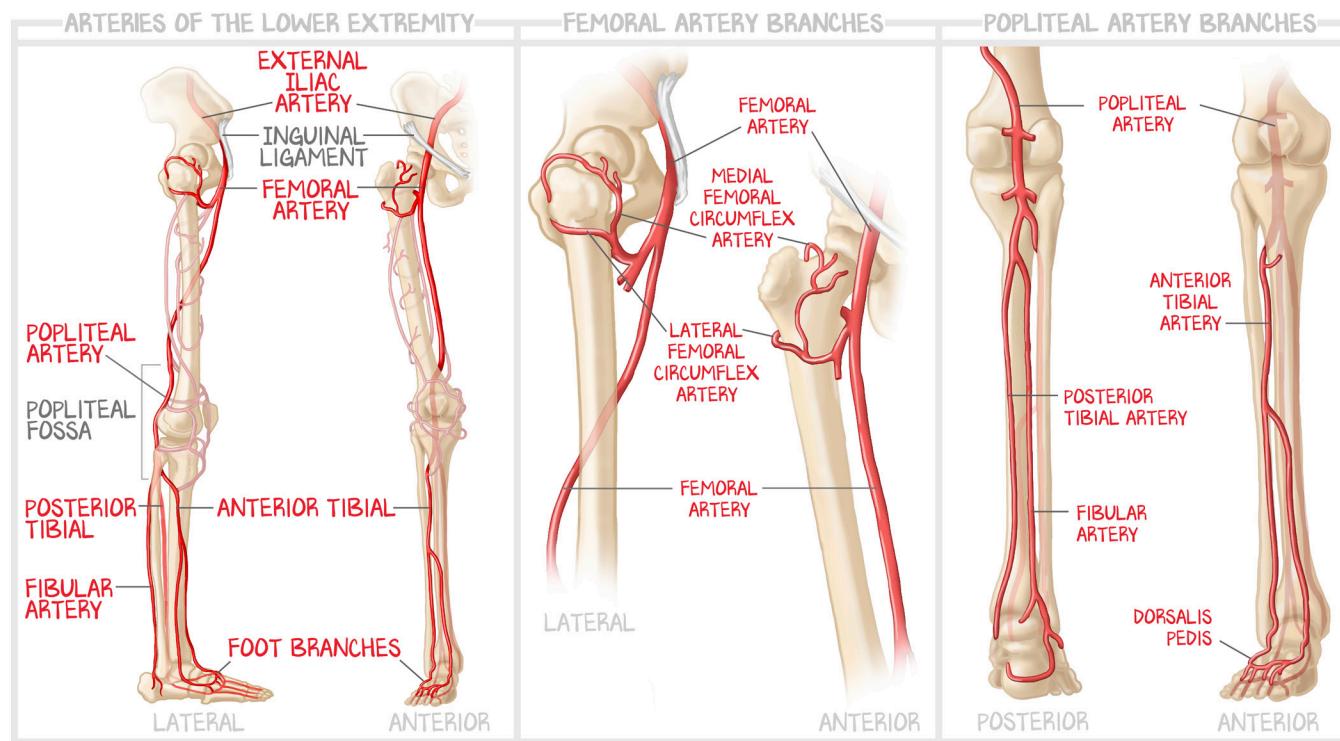


Figure 4.4: Arteries of the Lower Extremity

There are many arteries in the leg, most penetrating branches of the key vessels. The key branches of the femoral—medial circumflex, lateral circumflex—and the key branches of the popliteal artery—posterior tibial, anterior tibial, and fibular—are depicted without distracting vessels shown.

The femoral artery starts medial and anterior at the hip, then travels posterior and lateral as it approaches the knee. It exits the thigh through the **adductor hiatus** (an opening in the adductor magnus). Now posterior and exiting the posterior compartment of the thigh into the **popliteal fossa**, the femoral artery changes name to the **popliteal artery**. The popliteal artery then branches into the three arteries that irrigate the three compartments of the leg. The three compartments are the anterior, posterior, and lateral compartments. The popliteal branches into an anterior tibial , posterior tibial artery, and peroneal/fibular/lateral arteries. The **anterior tibial artery** travels into the anterior compartment, irrigates the anterior compartment, and travels along the tibia to become the **dorsalis pedis artery**. The **posterior tibial artery** remains in the posterior compartment, irrigating the posterior compartment, and travels over the ankle, where it retains its name, posterior tibial artery. Both the dorsalis pedis (dorsum of foot) and posterior tibial (at the ankle) are common locations to assess pulses. The peroneal/fibular/lateral artery irrigates the muscles of the lateral compartment.

COMPARTMENT	ACTION	NERVE	ARTERY	MUSCLES
Pelvis gluteal	Extension at hip	Inferior gluteal	Femoral	Gluteus maximus
Pelvis abductor	Abduction at hip	Superior gluteal	Femoral	Gluteus <i>otherus</i>
Thigh medial	Adduction at hip	Obturator nerve	Femoral	Obturator
Thigh anterior	Flexion at hip Extension at knee	Femoral nerve	Femoral	Quadriceps
Thigh posterior	Extension at hip Flexion at knee	Sciatic nerve	Femoral	Hamstrings
Leg lateral	Eversion at the ankle	Superficial peroneal/ fibular	Fibular/peroneal	N/A
Leg anterior	Dorsiflexion of ankle Inversion of ankle Extension of toes	Deep peroneal/ fibular	Anterior tibial	N/A
Leg posterior	Plantarflexion Inversion of ankle Flexion of toes	Tibial	Posterior tibial	N/A

Table 4.3: Summary of Compartments of the Lower Extremity